

on the parasites of the marine Mollusca. The locality beaten by the waves was by no means favourable, and I was only once able to find in the *Conus Mediterraneus* a fine flask-shaped Redia with a long, but usually retracted neck, a very large pharyngeal bulb, a short intestine, and a well-developed vascular system. I am compelled to confine myself to this mere indication, because the offspring which it contained was only in the state of germs.

#### XIV.—Observations on the Development of the Star-fishes.

By J. KOREN and D. C. DANIELSSEN\*.

SARS was the first to make known to us the history of the development of the Star-fishes, in Wiegmann's Archiv, x. p. 169. Subsequently, in the 'Fauna Littoralis Norvegiæ,' p. 47, he furnished complete observations upon the *Echinaster sanguinolentus*, Müller, and the *Asteracanthion Mülleri*, Sars. Here he described minutely the external changes passed through by the embryo until it acquires the radiate form. Unfortunately, he did not succeed in explaining the internal organization. The Star-fishes observed by Sars belong to the section in which the development takes place without any peculiar larval apparatus.

A short time afterwards, Desor † published the history of the development of a Star-fish, which took place nearly in the same way as that described by Sars, except that in place of four clavate prehensile arms, there was only one, which was always ventral, and placed near the middle of the Star-fish. With regard to this organ, Sars and Desor are at variance. Sars supposed that the four prehensile arms left a cicatrix, which became the madreporic plate. Desor, on the contrary, regarded the claviform prehensile arm as a vitellary sac, which diminished in proportion as the little Star-fish increased in size, until at last it disappeared altogether.

Subsequently, Agassiz ‡ published his observations, which for the most part agree with those of Desor, although he does not say that the claviform stem becomes an appendage of the digestive organs. Agassiz says that he has seen the contents of the stem turn upon themselves. W. Busch § observed and

\* Translated from the Fauna Littoralis Norvegiæ, Part ii. p. 55. By W. S. Dallas, F.L.S.

† Proc. Boston Soc. Nat. Hist. Feb. 15, 1848; Müller's Archiv, 1849, p. 79.

‡ American Traveller, Dec. 22, 1848; Müller's Archiv, 1851, p. 122.

§ Beobachtungen über Anatomie und Entwicklung einiger wirbellosen Seethiere, p. 77. Berlin, 1851.

figured larvæ exactly resembling those of Sars, and according to his observations the prehensile arms would disappear at last upon the ventral portion. Neither Sars, Desor, nor Agassiz speak of the mouth of the larva; Busch, however, asserted that he had seen one, between the four prehensile arms; but this he has given up, since Sars, who has had the opportunity of observing a multitude of larvæ, did not see the mouth.

J. Müller\* has minutely observed the larvæ of *Echinaster sanguinolentus*; but, unfortunately, this celebrated naturalist had only spirit-specimens, so that with regard to this point he could obtain no information. Having been unable to procure these larvæ, we are also compelled to pass over this question. According to J. Müller's observations, the prehensile organs are hollow, and have no relation to the digestive organs. In the interior of the body, at the side opposite to the prehensile organs, the stomach makes its appearance as a round body with a central cavity. It advances by degrees towards the middle of the body, in proportion as the larvæ acquire the radiate form. When the stomach is completely formed, the mouth opens at the point where it occurs in the adult Star-fish. After these remarks, we shall speak of the development of *Pteraster militaris*.

On the 9th of August 1852, we found this Star-fish with young in various stages of development. We know, from the observations of Sars, that the young of *E. sanguinolentus* and *A. Mülleri* are developed in a cavity situated in the vicinity of the mouth, and which is formed by the Star-fish drawing up its disk, collecting together the widest parts of its rays, and adhering by their tips. In *Pteraster militaris* there is a large hollow space between the skin, which bears the calcareous network and the spines, and the delicate soft membrane, which is supported and sustained by the spines, like a roof with numerous rows of pillars. At the middle of the back, this membrane has a large opening, which is pushed out like the neck of a bottle and surrounded by five small bundles of perfectly straight bristles. At the bottom, just at the middle of this, the anus opens. In the cavity above described the eggs are developed, and the young remain there until they have acquired the radiate form. It is only then that they pierce through the membrane above mentioned.

The number of young found in the cavity varies: in some specimens we have only found 8-10, in others 20, or even more. Most of the young occur along the arms, and only a few at the middle of the disk. The colour was usually yellowish, and most

\* Ueber den Allgemeinen Plan in der Entwicklung der Echinodermen. Berlin, 1853.

of the young had already acquired the radiate form, and were provided with eyes, which could be seen through the above-mentioned membrane. Unfortunately, we found none in the state of embryos, but we succeeded in finding some in the larval state. In these the body was of an oval form, a little waved in the middle, and at its upper part a buccal opening was perceived, which descended towards an extremely delicate intestinal canal. The larvæ being perfectly opaque, we were obliged to employ a careful pressure to show the internal organs. By this compression we saw that the skin was furnished here and there with calcareous particles; in other respects, the body was composed of a dark, granular mass. The buccal orifice appeared in the form of a funnel; it led to a delicate and narrow intestinal tube, of the same width throughout, except at its upper part, which was a little widened in the form of a funnel towards the buccal orifice.

The intestinal canal, after passing towards the posterior part of the body, made a curve to the right, and was then lost in the dark vitelline mass. In the interior of the body, and nearly in the middle, a mass of dark, closely-packed granules was observed (the commencement of the stomach of the Star-fish). This dark spot was already surrounded by a circular aquiferous canal. A hollow tube arose from the back of the larva (the commencement of the sand-canal), and terminated in the interior of the circular canal. We could not observe whether this tube had an external opening.

Another larva which we examined had five rounded rays at the margin. On the dorsal surface, towards the margin of one ray, there was a small, projecting, buccal orifice, which led to the delicate intestinal canal. When this larva was compressed, the buccal orifice and the intestinal canal appeared more distinctly, and although the latter was extremely delicate, it could nevertheless be traced to its opposite extremity, where it described a curve to the right, and opened upon the back of one of the rays. In the middle of the Star-fish a dark, round body (the stomach) was distinctly seen, with the aquiferous canal and the sand-canal which opened into it. No trace of ambulacra could be discovered, but, on the other hand, several irregular calcareous pieces were seen in the mass of the body.

The third young animal was much larger, and had five obtuse rays distinctly developed. At the middle of the extremity of each ray there was an eye, composed of three pigmentary agglomerations, formed by dull orange-coloured pigment-granules. The larval mouth, which was slightly prominent, was situated to the left between two rays. The intestinal canal and the anal orifice could still be seen distinctly. Calcareous spines had been



formed in the skin. At the middle of the back there was an opening, just at the spot where the prominent orifice, in the form of the neck of a bottle, occurs in the adult animal. In the middle of the ventral plane the buccal orifice was observed, surrounded by five calcareous pieces, and closed by a pretty strong membrane. The stomach was distinctly formed, and surrounding it the aquiferous canal already mentioned was observed, from which five canals passed to the five rays. From each canal lateral canals issued, which terminated in the pedal vesicles. In this specimen there were three pairs of ambulacra.

On the 12th of August we again examined some specimens. The larval mouth still existed, but a portion of the intestinal canal of the larva had already begun to disappear. On the back, which was tolerably convex, the madreporic plate was found in an interradiial space. Four pairs of ambulacra were formed. The skeleton was then pretty well developed. The membrane which closed the buccal aperture still existed; it does not disappear until afterwards, so that the true mouth is only formed after the young animal has quitted its mother.

If we glance at the observations which we have made upon the development of *Pteraster militaris*, we shall see that the embryo passes through three stages,—the embryonic state, that of the larva, and that of the Echinoderm, all of which are passed through whilst the embryo is enclosed in the maternal cavity. On comparing this, in the first place, with the Star-fishes whose larvæ are furnished with claviform prehensile organs, but nevertheless, as regards the development of the other internal organs, are still in the embryonic state, and then with those which have special larval organs which subsequently disappear, we shall find that the development of *Pteraster militaris* differs in several points from that of those larvæ. In *Pteraster*, the form of the larva is oval, without prehensile arms, and it is furnished with a buccal orifice, and with a long and narrow intestinal canal, which terminates by an anal orifice. Both the mouth and the remainder of the intestinal canal disappear by absorption, but only some time after the true Echinoderm has made its appearance. Even in the larva the rudiment of the stomach of the future Star-fish is perceived; this, however, does not arrive at its perfect development until the radiate form has made its appearance. For some time the larval mouth and the intestinal canal and anal opening are still observed; for it is only at a later period of development that all these attributes disappear, after the formation of a mouth in the centre of the ventral surface and an anal orifice on the back.

In *Bipinnaria asterigera* the œsophagus of the larva enters into the back of the Star-fish excentrically and interradially:

Near to it, and a little to the left, the anal tube is situated, at a considerable distance from the centre of the Star-fish.

In *Pteraster militaris* the larval mouth only presents itself upon the back near the margin of two arms, in the most advanced larval state; and the anal orifice is situated here, as in *Bipinnaria asterigera*, excentrically. In *Bipinnaria asterigera*, in which the Star-fish only communicates with the larva by the œsophagus and the skin which passes from the larva to the Star-fish, the larva detaches itself from the latter by the œsophagus becoming constricted with strong contractions, whilst the detached larva dies in six or eight days. We have also observed that the whole intestinal canal disappears, and that a new anal orifice is formed; it is only the stomach that remains of the larva. This takes place somewhat differently in *Pteraster militaris*, for the entire larva passes into the Star-fish, although the latter receives a new mouth, intestinal canal, and anus. J. Müller has indicated that *Bipinnaria asterigera* is perhaps a stage in the development of *Solaster furcifer*. It is now some years since we expressed the same opinion on this subject to MM. Sars and Bockdaleck.

#### BIBLIOGRAPHICAL NOTICES.

*System der Ornithologie West Afrika's von Dr. G. HARTLAUB.*  
Bremen, 1857, 1 vol. 8vo.

UNTIL the local faunæ of the different parts of the earth's surface have been worked out to a much greater extent than has as yet been accomplished, it is almost hopeless to attempt with any certainty to enunciate general laws on the geographical distribution of animal life, one of the most interesting and by no means one of the least important subjects of natural science. It is with great pleasure, therefore, that we welcome every successive attempt to form an accurate account of the whole or any part of the animated nature of particular countries. Africa is a zoological kingdom to which the naturalists of Germany have of late years devoted no small degree of attention. Since Dr. Rüppell completed his great contributions towards our knowledge of the zoology of North-eastern Africa, Vieithaler, A. Brehm, Von Müller, and Prince Paul of Wurtemberg, have made further explorations into more remote portions of the same country, and have reaped a rich harvest of results; and Dr. Peters, returned from the little-known region of the Mozambique, has commenced the publication of his numerous discoveries in every branch of zoology. To the ornithology of Africa, Dr. G. Hartlaub of Bremen has for several years devoted much of his attention; many papers in the Transactions of the Natural History Society of Hamburg, and in Cabanis' 'Journal für Ornithologie,' bearing witness to his untiring